Auditory attention: One term for several concepts?

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Characterizing Auditory Attention

Motivation

The use of spectrally and temporally complex stimuli is increasing.

Models based on peripheral processes do not always explain the results.

Psychoacousticians are beginning to use (and argue over) terms like “attention.”

Goal

Examine some past and present uses of the term “attention” and argue that there may be some useful distinctions that are not always clearly stated.

Argue that we are really interested in determining the various mechanisms that make up this phenomenon we call attention.

Characterizing Auditory Attention

Organization

1. Brief History of Some Topics in Auditory Attention
2. A Specific Example of Divided Attention with Auditory Stimuli

Some History…

Wundt (1879)

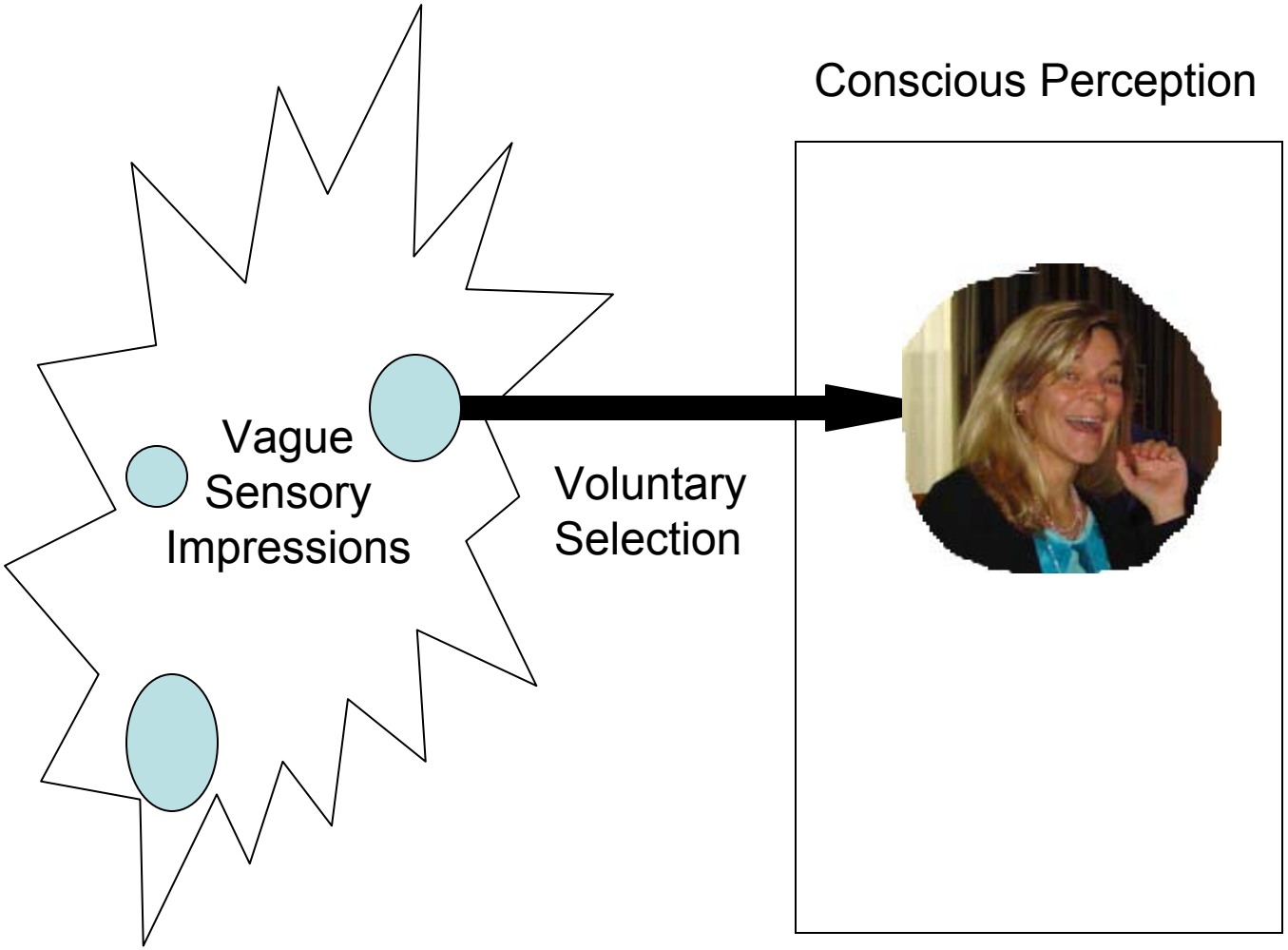
apprehension: admitting a vague sensory impression into consciousness

apperception: a voluntary act of will by which a vague sensory impression becomes clearly perceived

This implies two automatic (involuntary) processes:

- apprehension of vague sensory impressions and
- the process by which the details are clearly perceived

Wundtian Perception

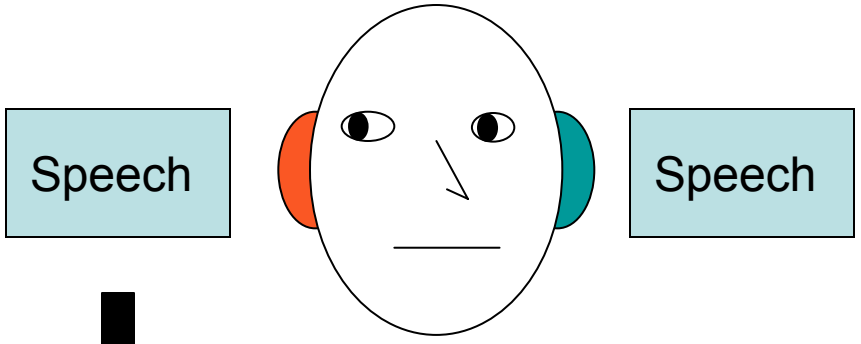


Apprehension

Apperception

Wundt's (1879) conception is not that different from that of Cherry (1953) and Broadbent (1958)

No Selection:
Vague Sensory Impressions



Voluntary
Selection

After Voluntary Selection:
Intelligible Speech

Ready Baron Go to Blue Four

How "vaguely" perceived is an unselected stimulus?

Much of this talk (and indeed this session) will concern the question of the unselected stimulus.

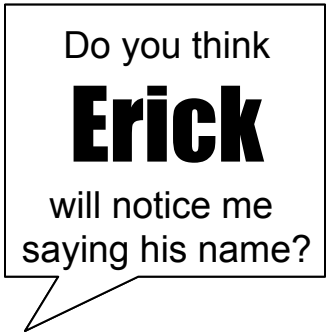
However, let us pause to note that we have now identified two distinct types of processing available to the listener, both of which have been called aspects (or varieties) of “attention”.

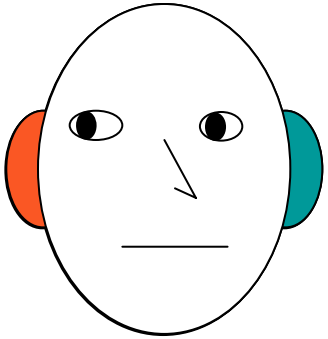
Varieties of Attention

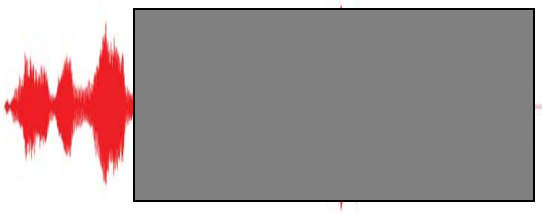
1. Automatic Detection of Sensory Objects (‘vague impressions’)
2. Voluntary Selection, followed by Automatic Recognition

Are there other varieties of auditory attention?

What about objects that “grab” attention?







Ready [mzrph mrrphl gglrmph rph]

As Deutsch and Deutsch (1963) noted (and others have confirmed), listeners instructed to focus on one speech stimulus and ignore another are much more likely to respond to the unattended input when their own name is spoken.

In the study of visual psychophysics, there have been many examples of "automatic" recognition of unselected objects.

The most successfully documented (Jonides and Yantis, 1988) involves abrupt stimulus onsets.

Perhaps in audition as well, some objects become automatically selected for further analysis.

What properties determine this? Do onsets play a similar role in audition? Can we identify the mechanism(s) responsible?

For now, we will simply add "automatic selection" to the list we are compiling.

Varieties of Attention

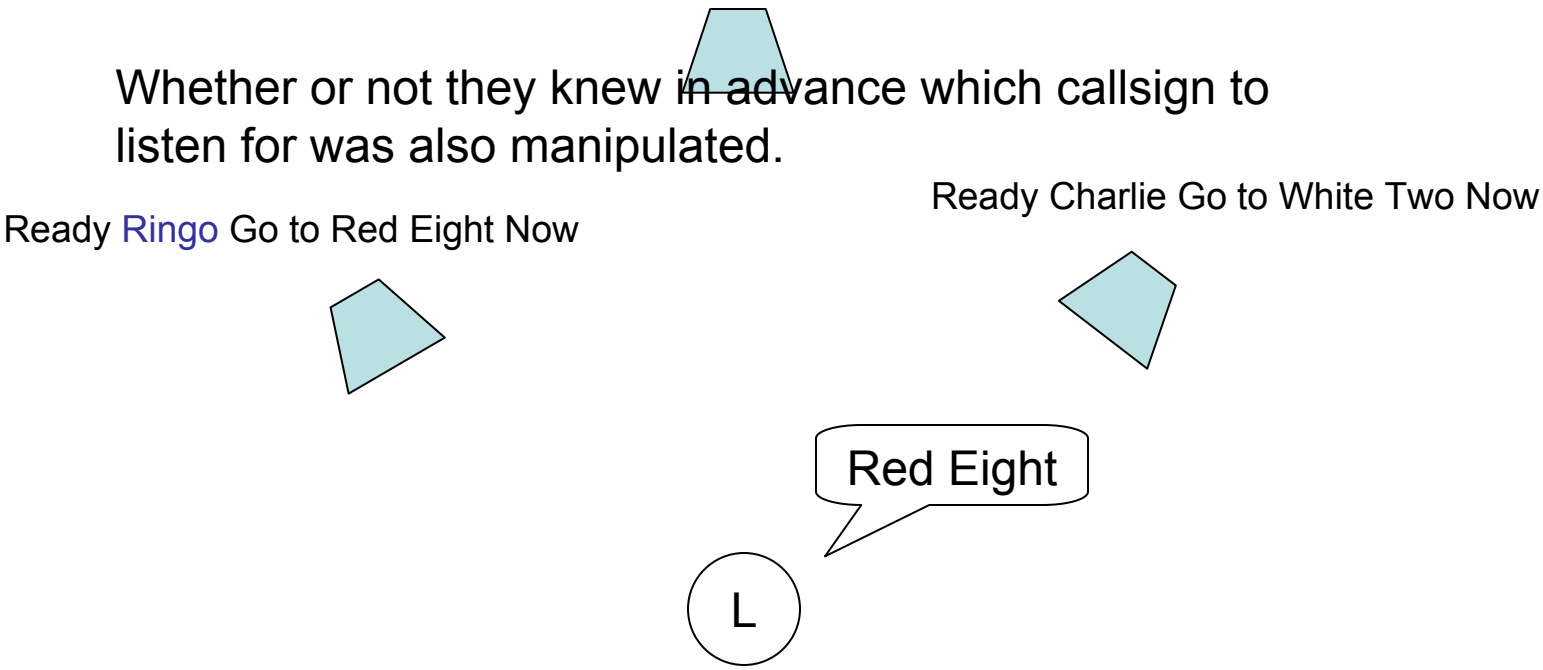
1. Automatic Detection of Sensory Objects (‘vague impressions’)
2. Voluntary Selection, followed by Automatic Recognition
3. Automatic Recognition of (Some) Unselected Objects

As a side note, Lavie and Tsal (1994) proposed that the total “processing load” determines the extent to which unselected objects get processed. So far this has been only tested in audition once…

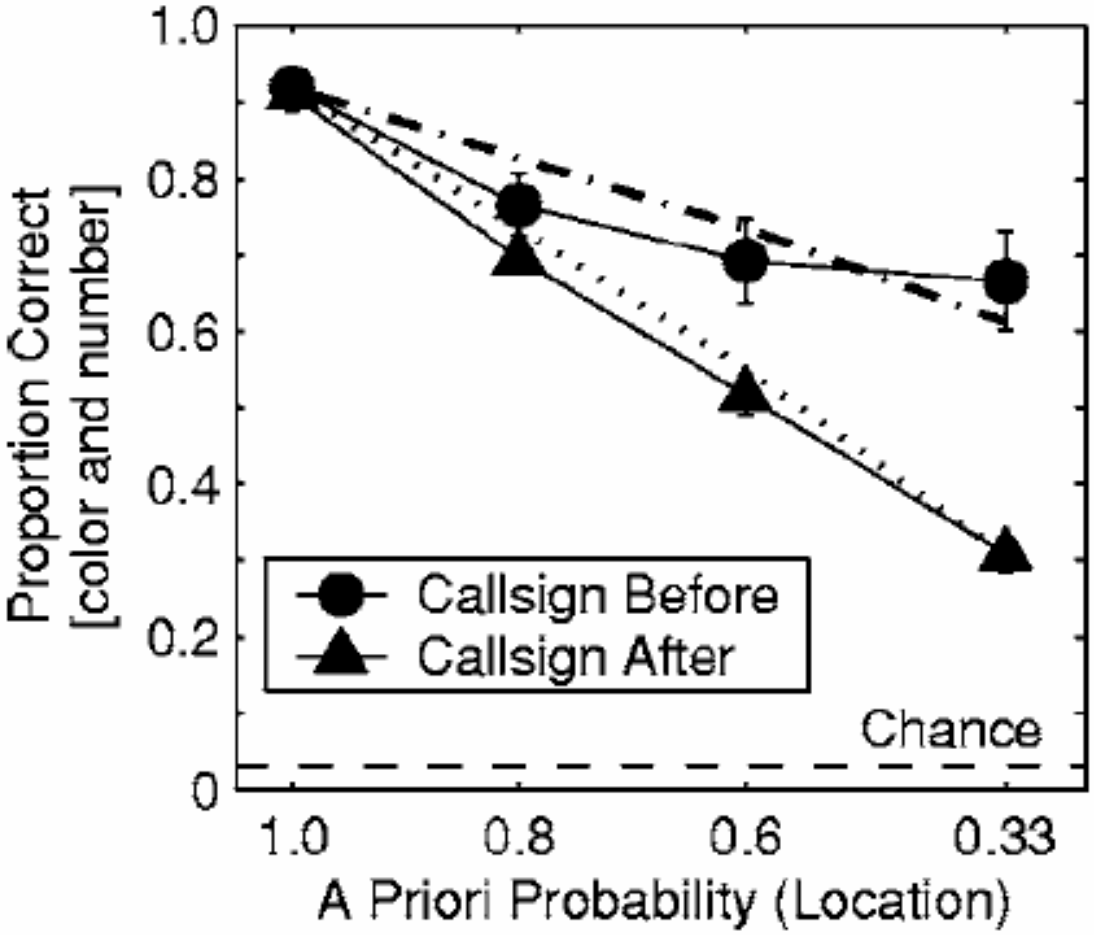
Another "variety" of auditory attention involves a listener's expectations of where a target will appear in time, frequency or spatial location.

This was shown recently in a multiple-source listening experiment where listeners were (or were not) told where to listen on a probabilistic basis.

Whether or not they knew in advance which callsign to listen for was also manipulated.



Kidd, Arbogast, Mason and Gallun (2005)
"The advantage of knowing where to listen"
JASA 118(6)

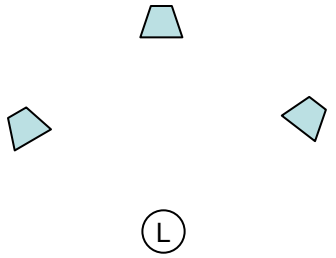


Listeners were much more successful when they were told in advance

- which callsign to report

or

- where to listen for the target.



Note that these results suggest that listeners can NOT process multiple targets simultaneously…

Varieties of Attention

1. Automatic Detection of Sensory Objects (‘vague impressions’)
2. Voluntary Selection, followed by Automatic Recognition
3. Automatic Recognition of Some Unselected Objects
4. Expectation of Where or When a Target will appear.

Are there more?

Undoubtedly.

This does not exhaust the list of phenomena that have been called "auditory attention".

Several of the talks in this session will present data that probably are not easily captured by the previous list.

However, the previous examples do make the points that

1) **characterizing auditory attention is not a simple matter and**
2) **many central questions still remain unanswered.**

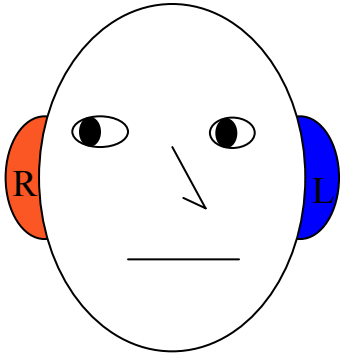
The remainder of the talk will focus on a specific line of experimentation on auditory attention involving many of the issues discussed previously.

In addition, the results will be used to suggest one of the ways that basic mechanisms of auditory perception can be revealed by studying attention.

Comparing selection of one and two auditory stimuli

Single-task, single-stimulus

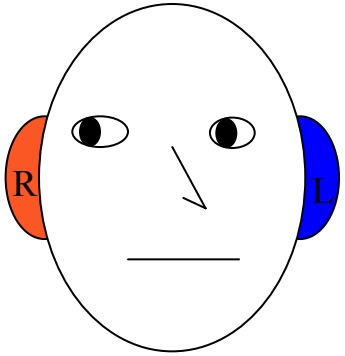
Target



Single-task, dual-stimulus (selective attention)

Target ear known in advance

Target

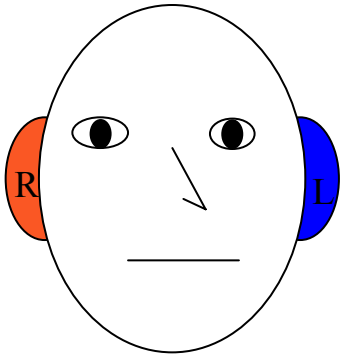


Masker

Dual-task, dual-stimulus (divided attention)

Target ear unknown in advance

Target One



Target Two

Stimuli

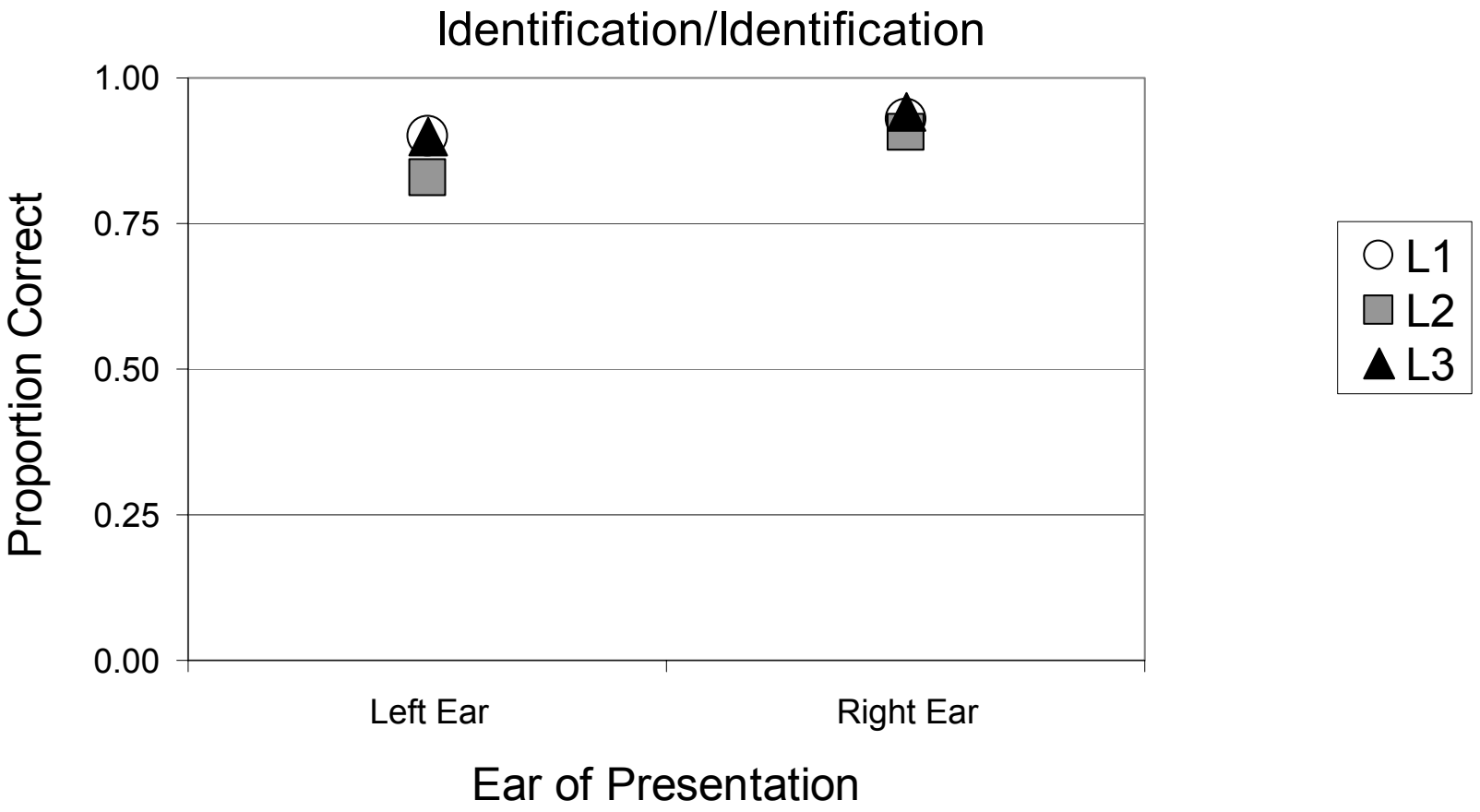
Unprocessed sentences presented in noise. 
Noise level chosen for each listener so that performances is at about 85% correct with only one input.

New target and masker sentences chosen on every trial.

Tasks

Identification of keywords 
Detection of speech in noise 

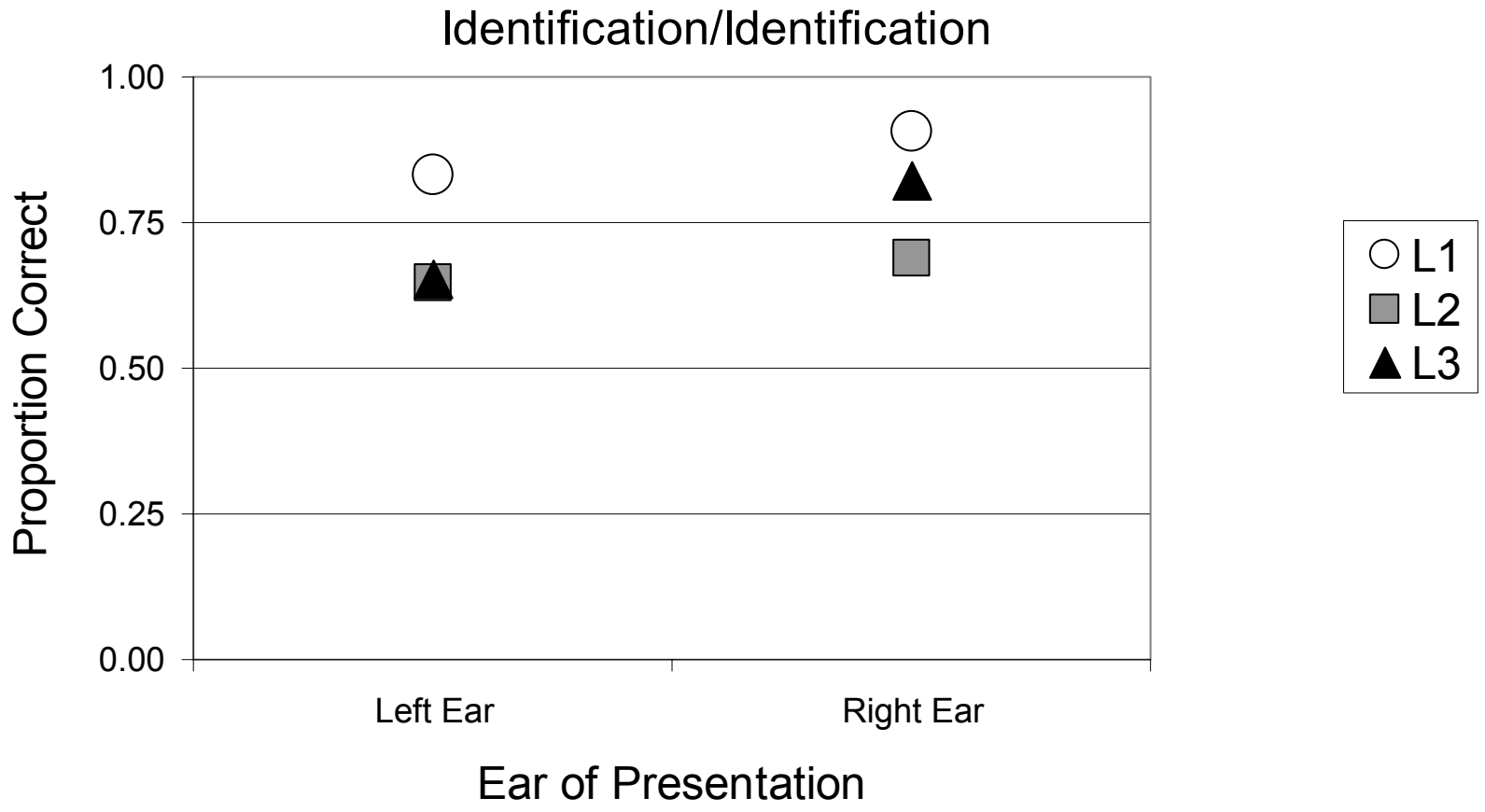
Single-task, single-stimulus



Single-task, dual-stimulus

Target ear known in advance

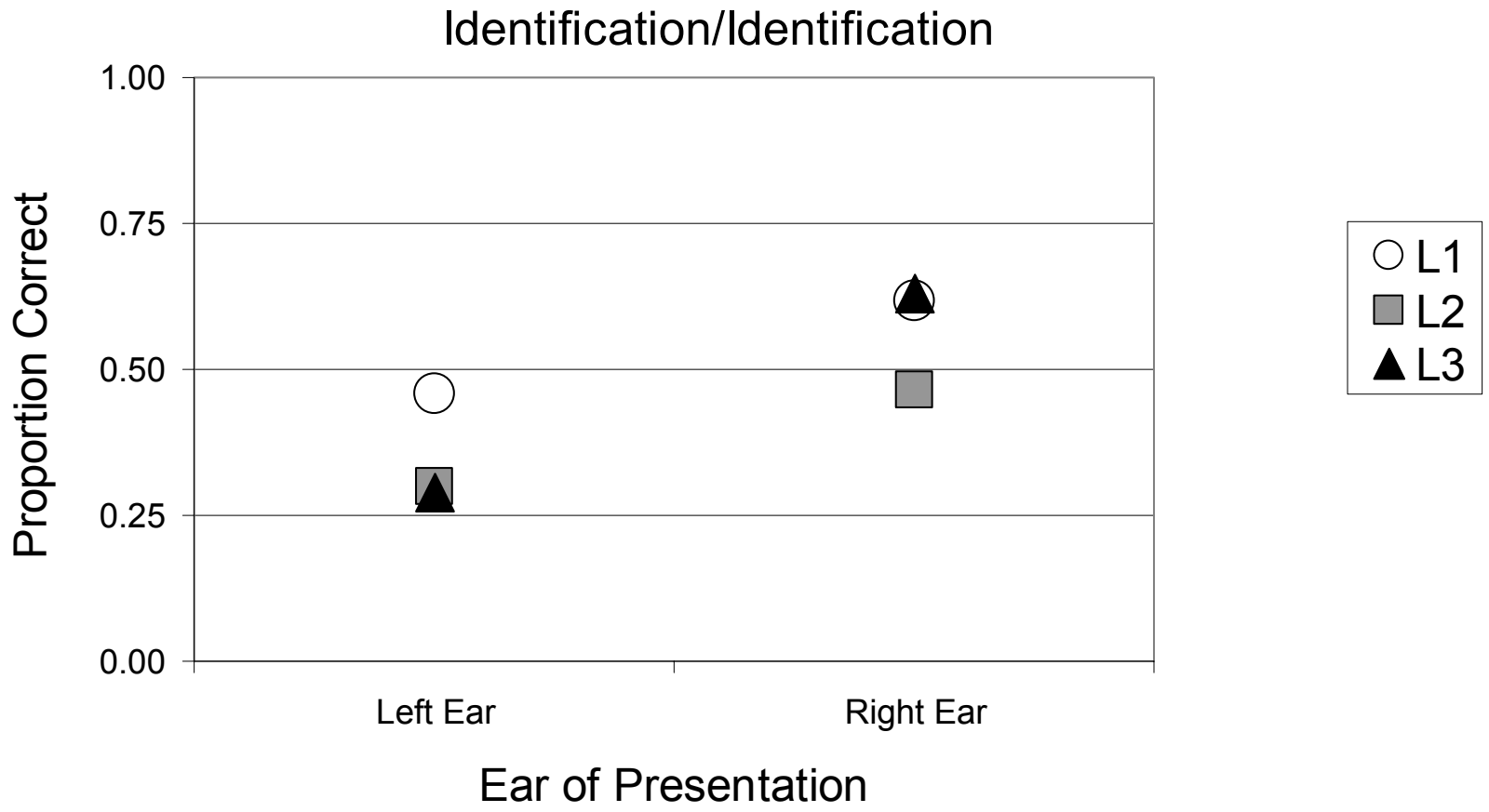
Selective Attention



Dual-task, dual-stimulus

Divided Attention

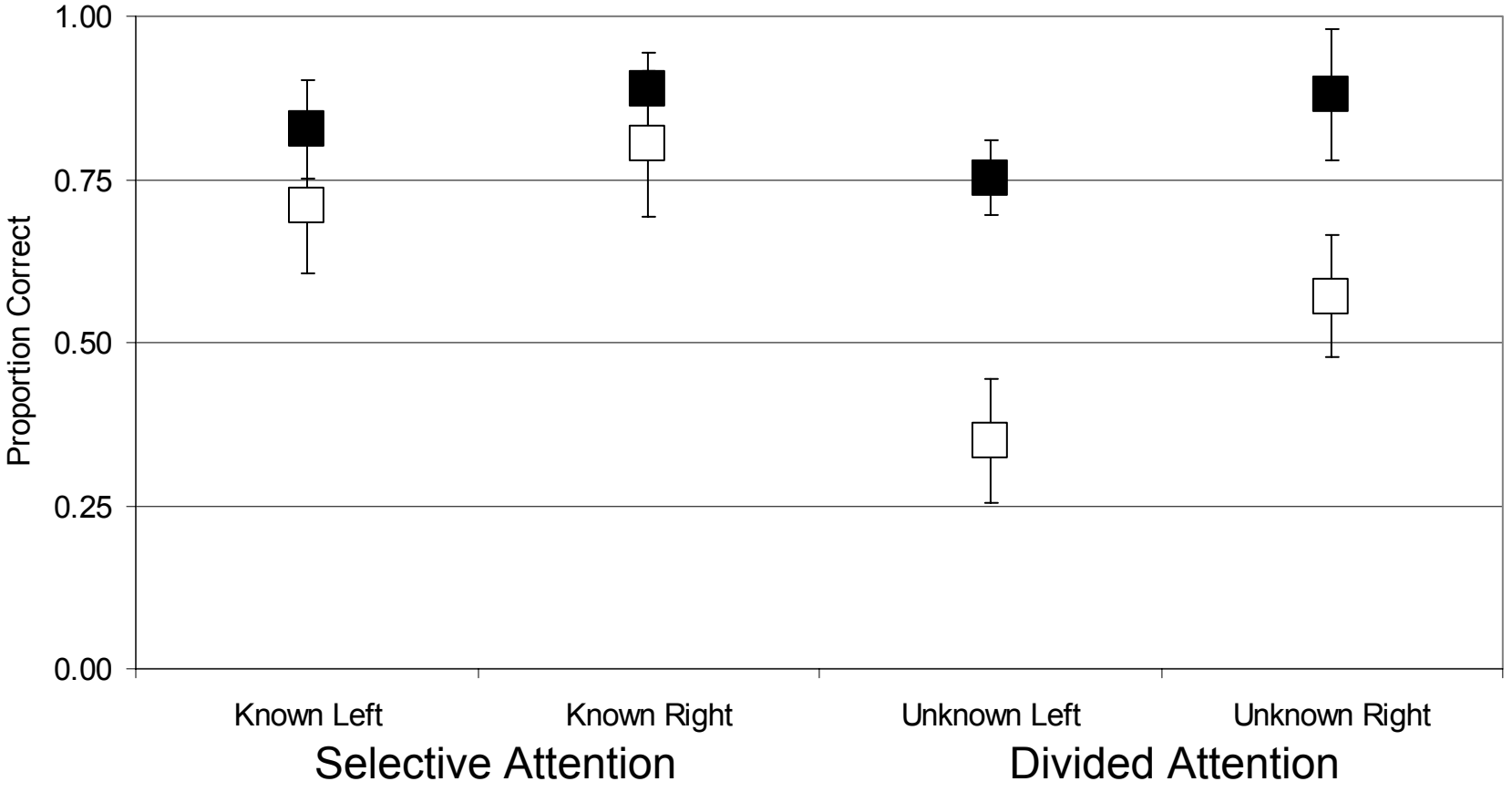
Target ear unknown in advance



Is this always the case? What if you were asked to perform a different task on each? Would that make things harder or easier?

Condition 1: Identification on both sentences (ID/ID)

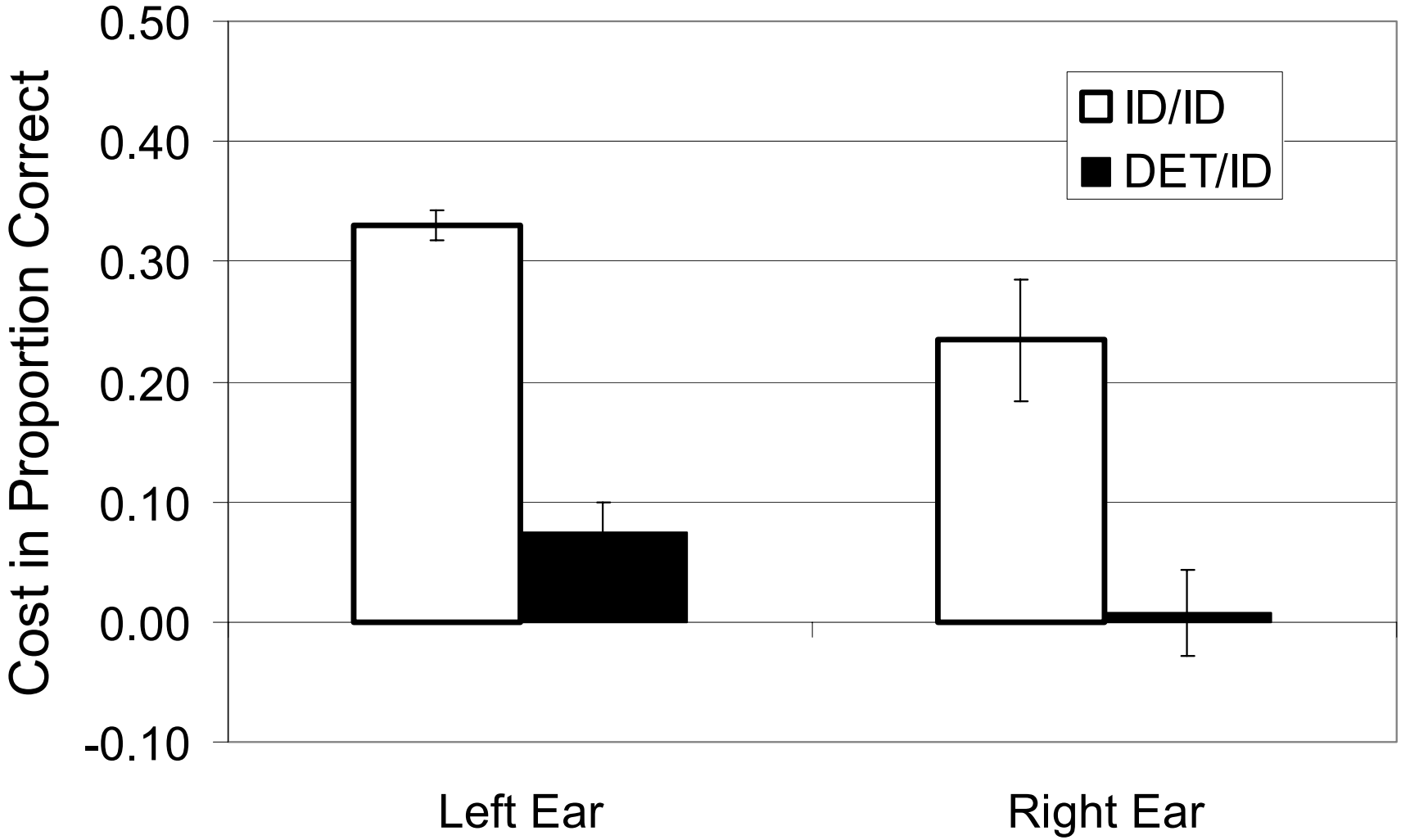
Condition 2: Identification on the right; Detection on the left (DET/ID)



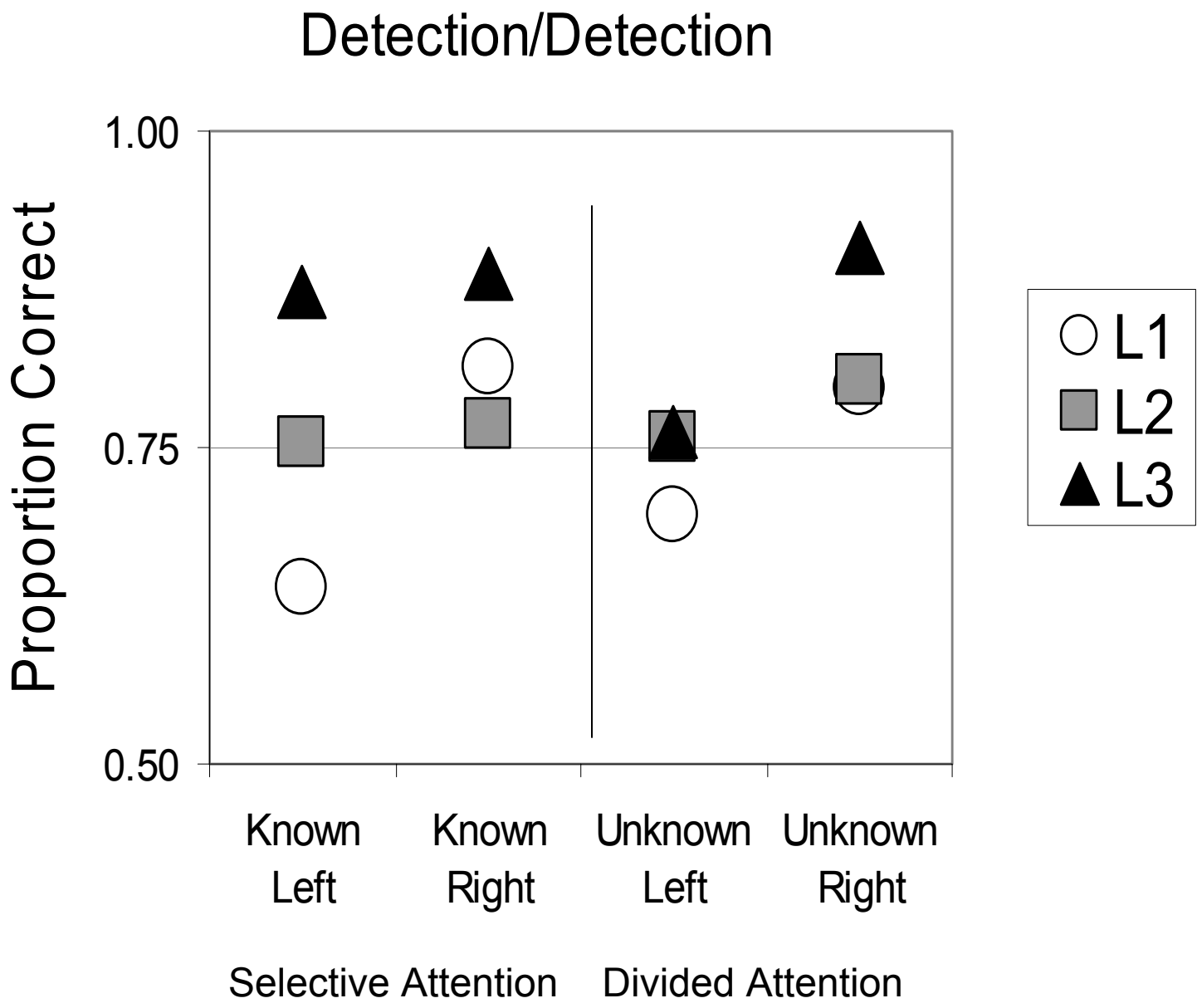
This means that listeners could simultaneously process both stimuli, but only when the tasks were different.

In order to simplify the presentation of results, we are going to focus on the cost of *divided* attention.

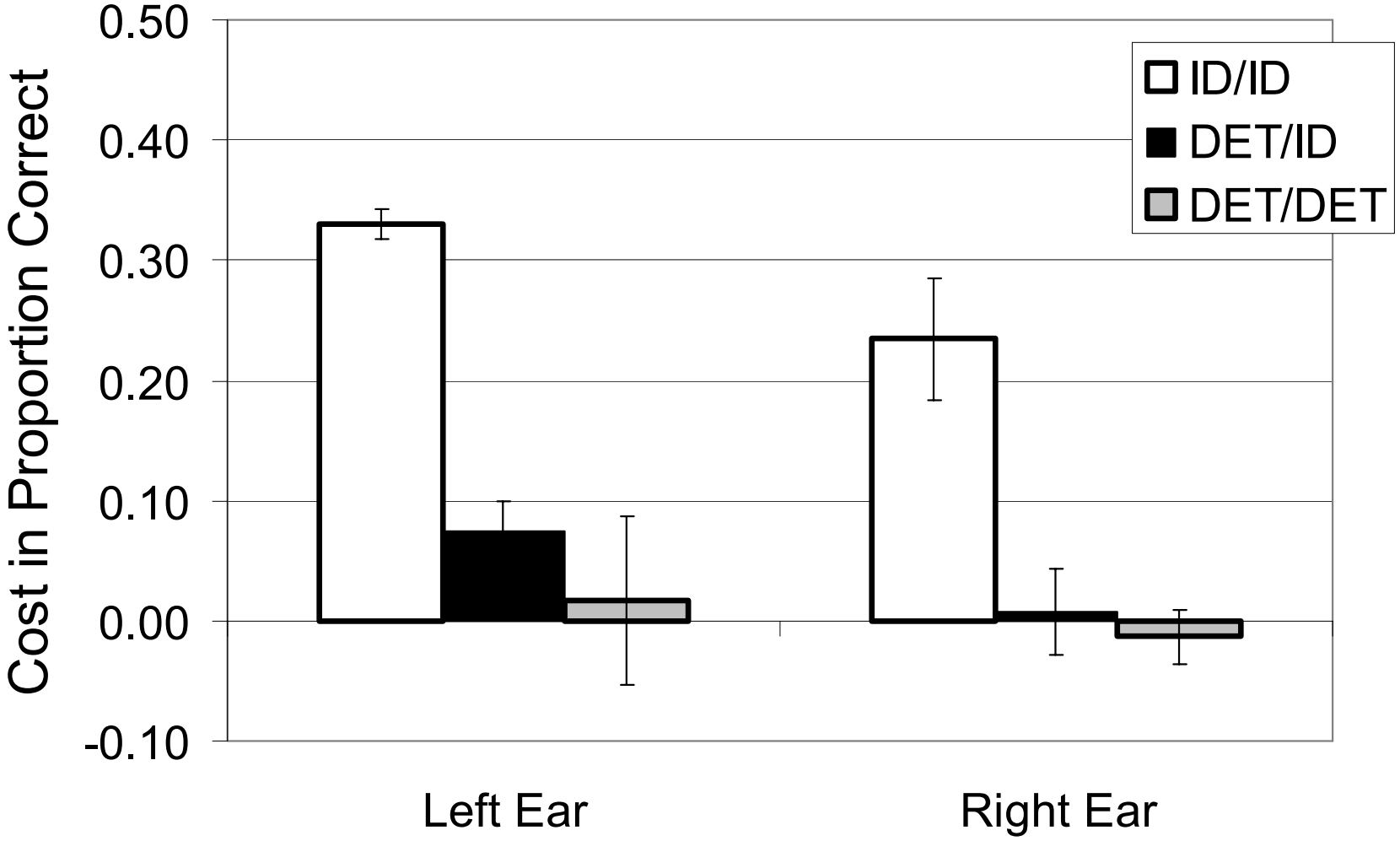
Cost will be operationalized as the difference between selective and divided attention.



Is there something special about detection?



The cost of dividing attention seems to be related to performing two simultaneous identification tasks.



How do these results fit with the processes we described before?

Varieties of Attention

1. Automatic Detection of Sensory Objects (‘vague impressions’)
2. Voluntary Selection, followed by Automatic Recognition
3. Automatic Recognition of Some Unselected Objects
4. Expectation of Where or When a Target will appear.

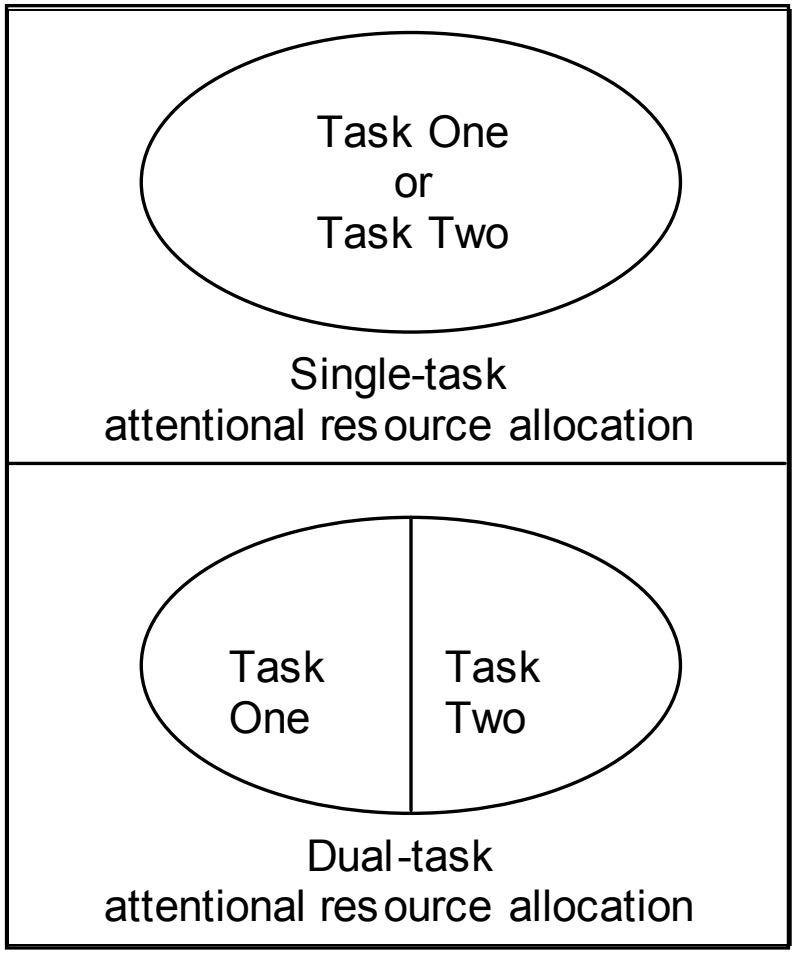
Selective attention to one ear involves voluntary selection based on expectations of where (and when) a target will appear.

Divided attention may involve voluntary selection, in the case of speech identification, and automatic detection (or recognition) in the case of speech detection.

If detection is automatic, then it makes sense that there is no cost.

But what mechanisms could be responsible?

Explanation #1
Shared Resources

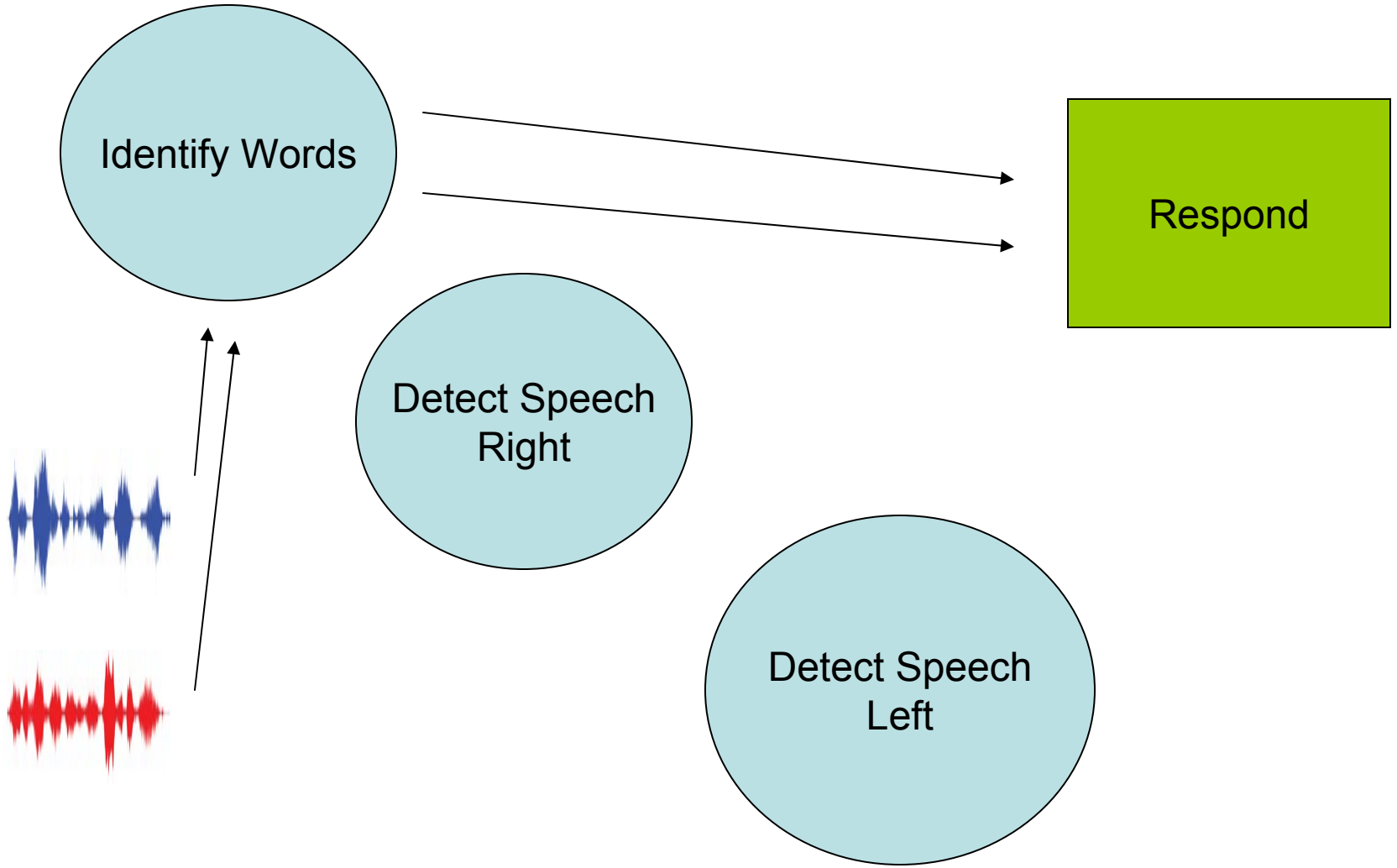


(Norman and Bobrow, 1975;
Navon and Gopher, 1979)

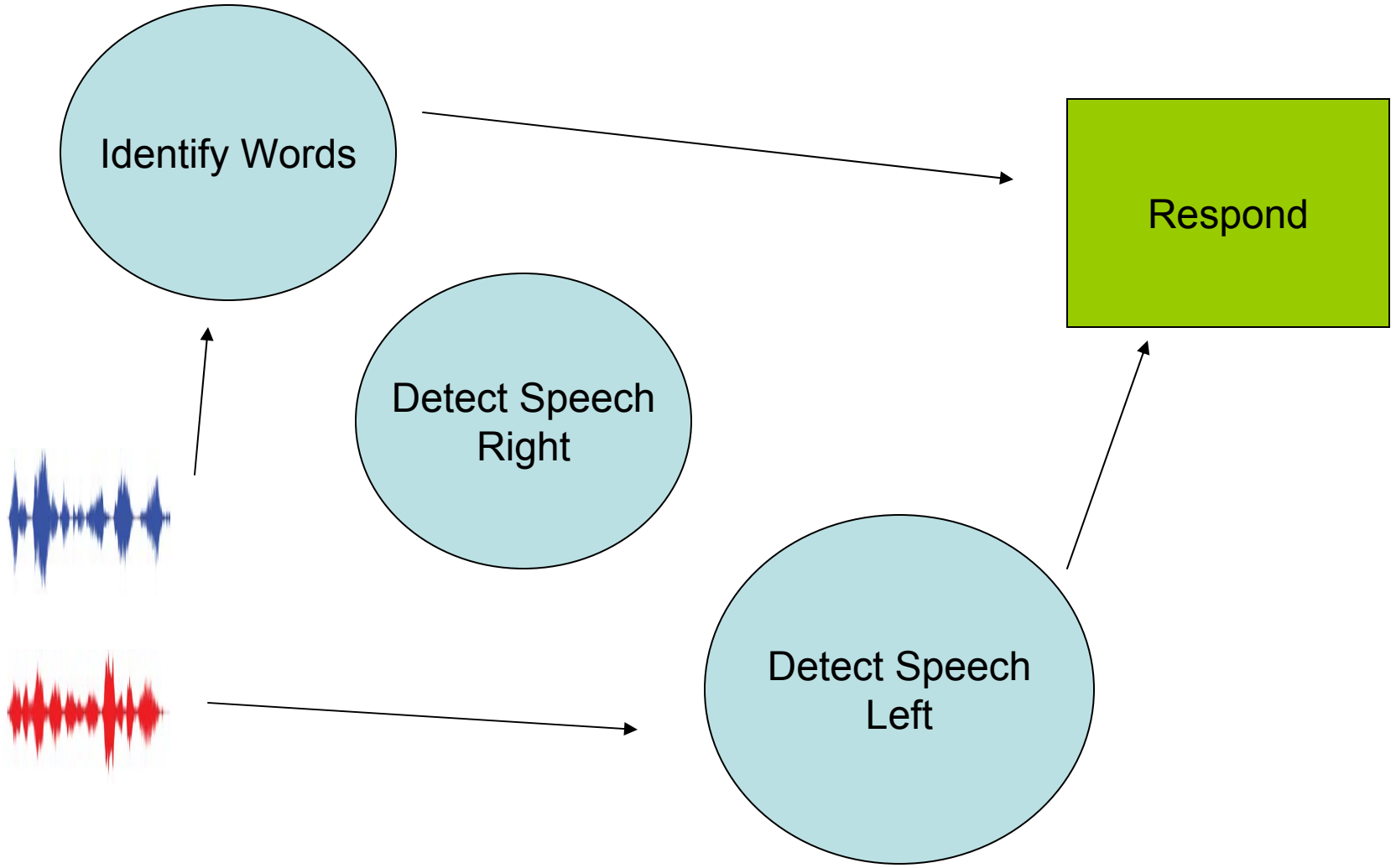
A resource explanation assumes that performance is limited by the voluntary allocation of limited processing resources.

An "automatic" process is one that draws on a different pool of resources, so no division is needed.

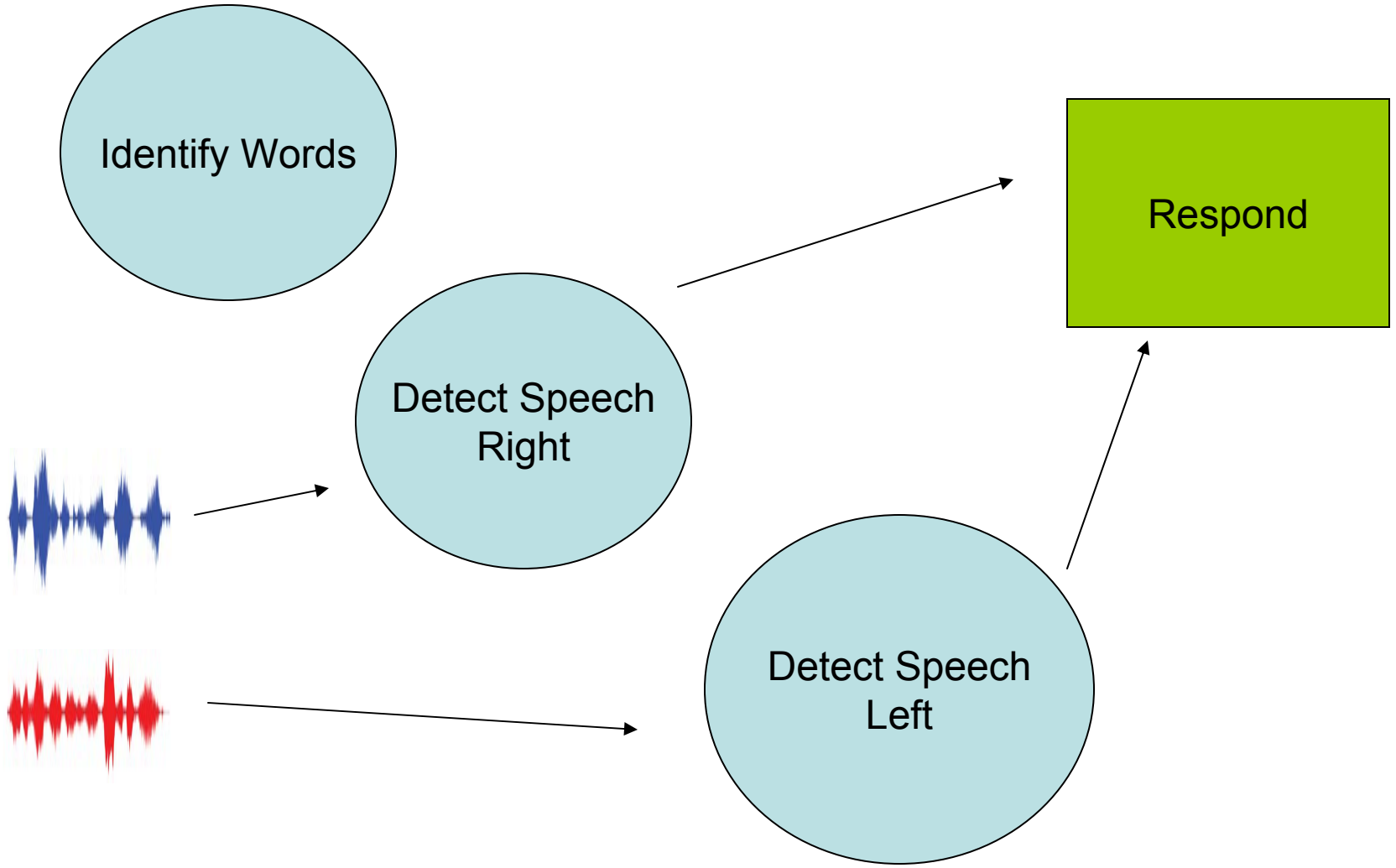
Shared Resources for Identification/Identification



Independent Resources for Detection/Identification



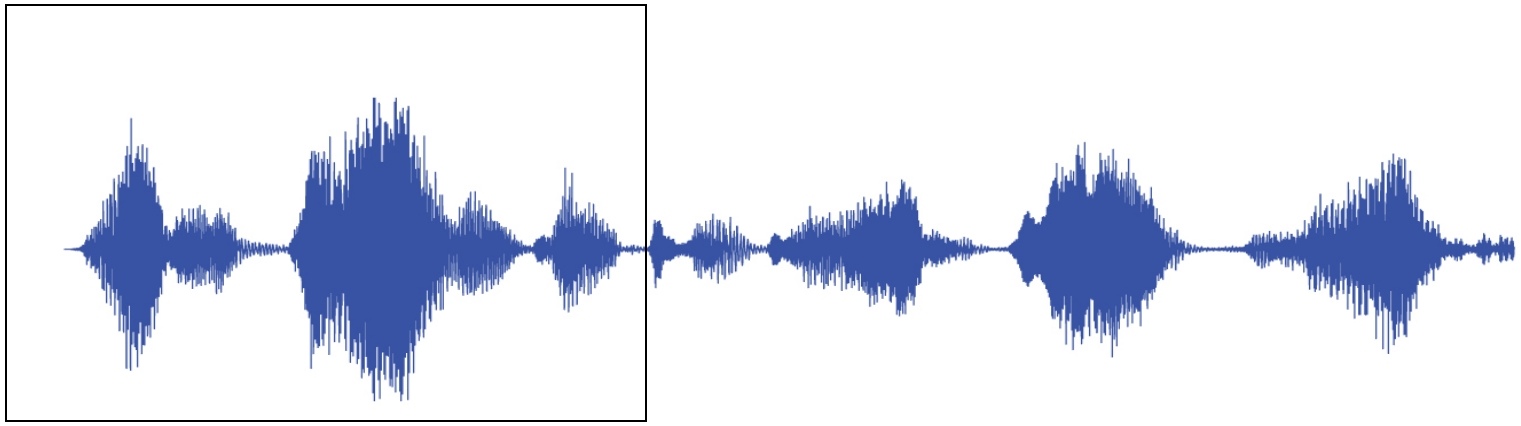
Independent Resources for Detection/Detection



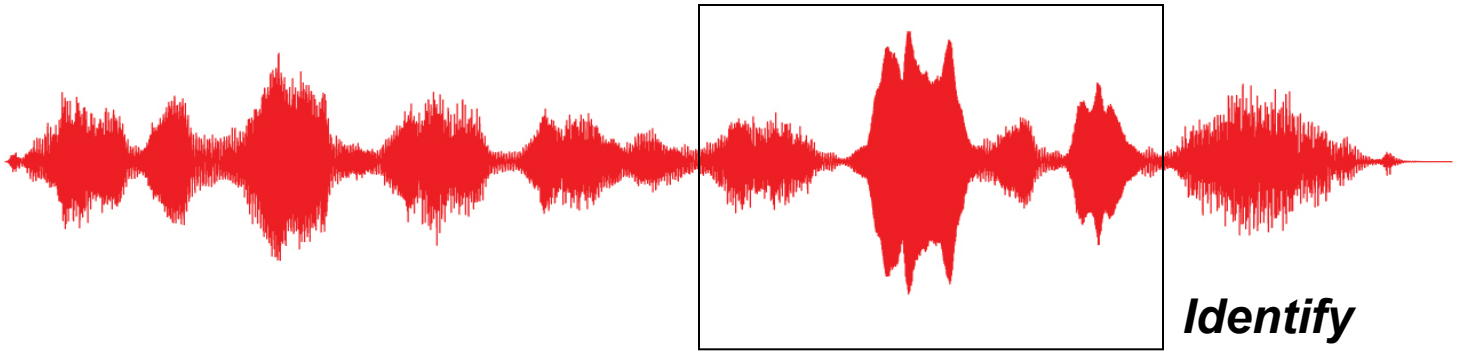
Explanation #2: Task-Switching

On the other hand, “automatic” processing could just be processing in serial, rather than in parallel.

Detect



“Ready [callsign] go to [color] [number] now ”



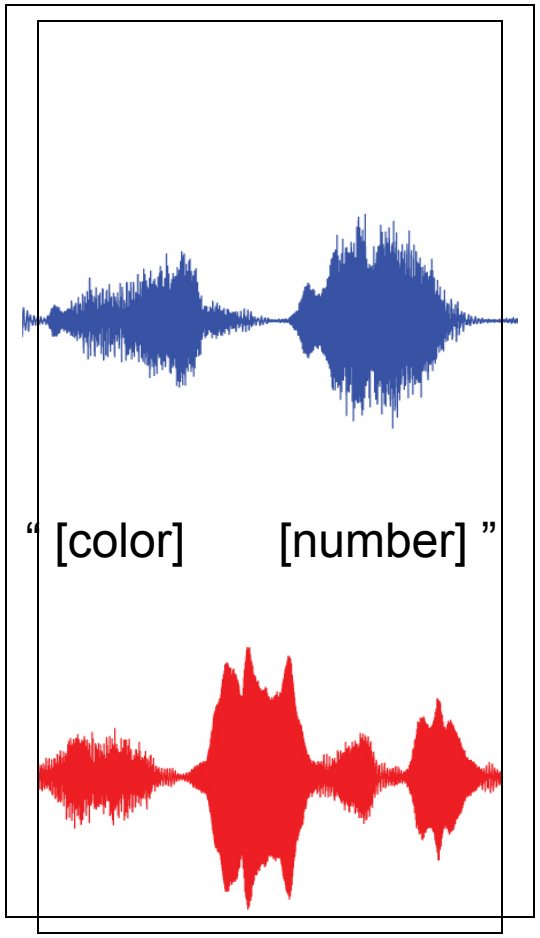
Identify

However, in a previous study with processed speech stimuli, we compared performance with the full sentences to a condition with shortened sentences.

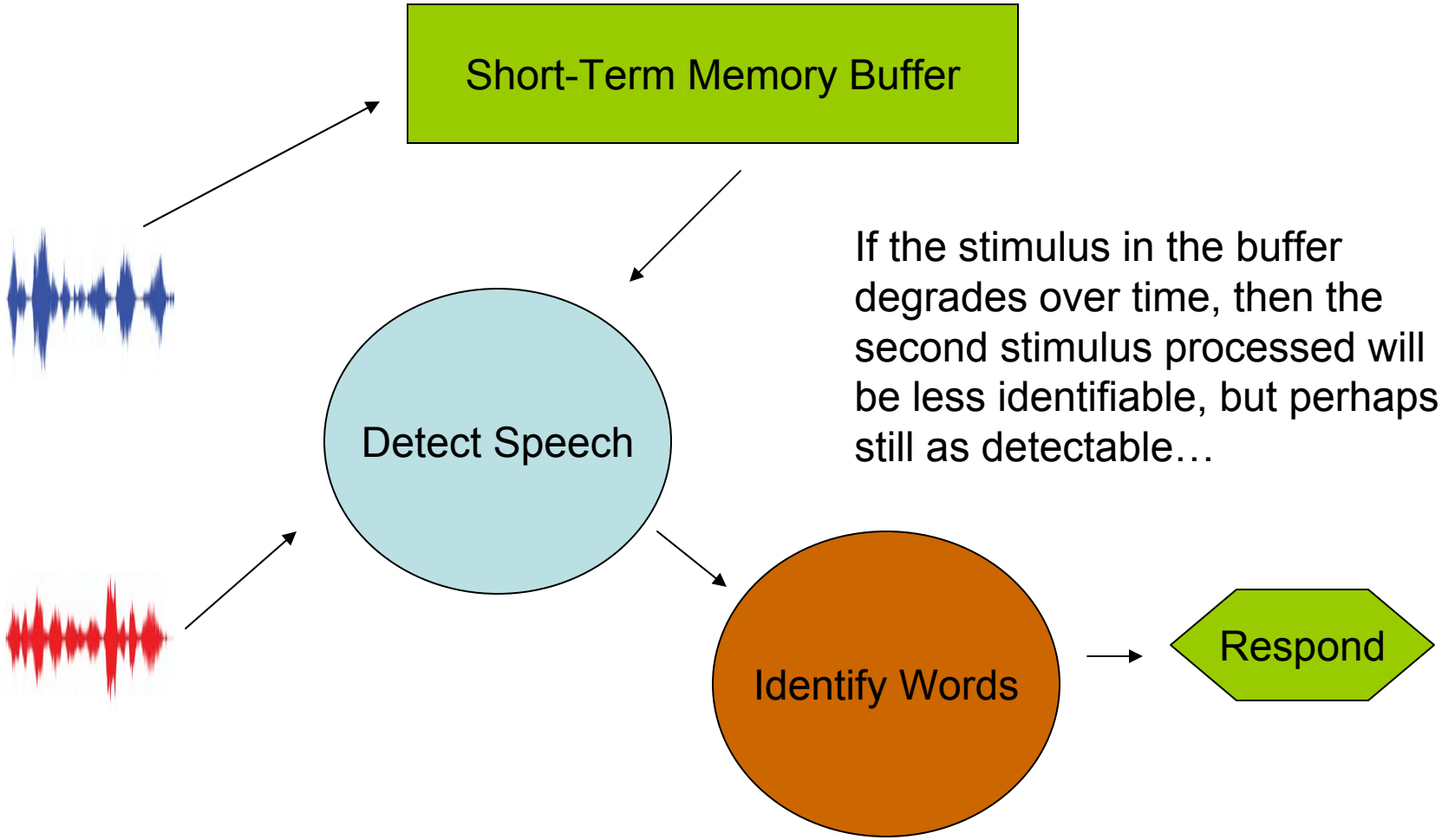
There was no change in the cost of performing both an identification and a detection task.

Perhaps they were still switching, but at a higher rate.

Identify
Detect



Explanation #3: Memory



If the stimulus in the buffer degrades over time, then the second stimulus processed will be less identifiable, but perhaps still as detectable…

In this case, “automatic” processing is based on using a stored copy. Again, a serial process rather than one that happens in parallel.

By studying interference in this way, a number of testable hypotheses related to the structure of the human information processing system can be developed.

Future work on the processing of complex stimuli is most likely to make progress by engaging and exploring these types of potential explanations.

What else can attention tell us?

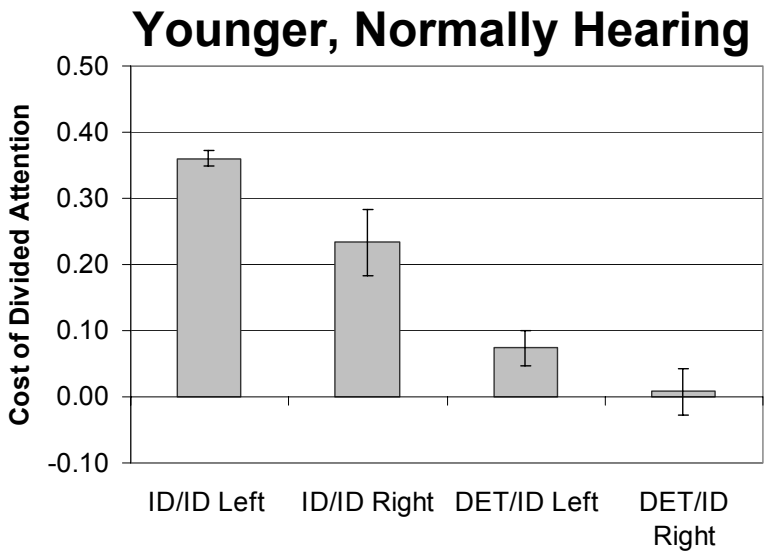
All of the listeners were young with normal hearing -

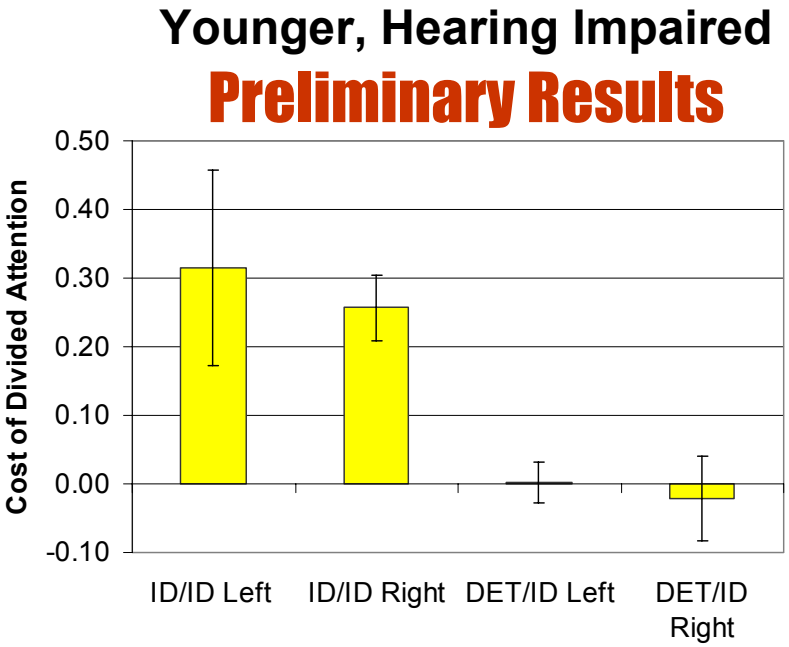
Does this result hold for older and/or hearing-impaired listeners as well?

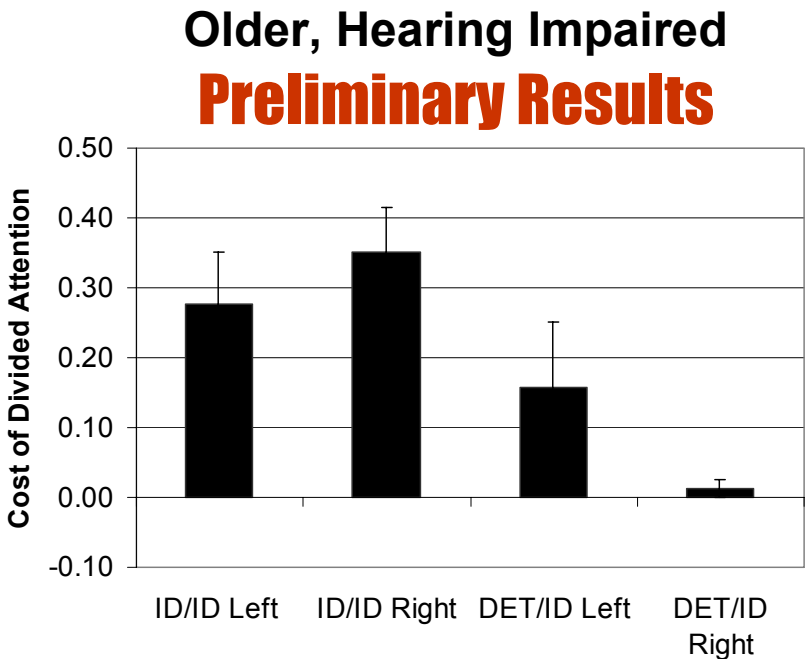
If not, we will have identified a potential cause of difficulties by these two extremely interesting and important populations.

Luckily, we have some preliminary data!

Cost of Divided Attention







The one obvious difference between our listener groups is associated with the ability to perform the detection task.

Is task-switching more difficult for older listeners? Is there a rate limit?

Or perhaps is there a memory component that is harder for them?

Conclusions
(and Preface to the rest of the session)

- "Attention" is useful as a description (like "hearing") but the real work to be done involves characterizing the various mechanisms that are implied.

- The goal of this talk was to give a concrete example in support of the argument that studying attention can generate testable hypotheses about the underlying structure of the auditory system (regardless of the words we use to describe the phenomena).

- Future work on attention may also allow us to better understand the individual differences that are so prevalent in studies of complex stimuli.

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